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ABSTRACT

This paper examines the methodological literature of cross-cultural research to establish whether the means exist to identify culturally biased preconceptions implicit in human-computer interfaces, and to develop interfaces more attuned to the cultural differences of the users. It is the premise of this paper that cultural conditioning affects individuals' responses to technology and that in developing nations such conditioning can seriously impede the transfer of information and gains in productivity anticipated from the use of computerized equipment. The review of research methods examines questions of research design, tool construction, measurement, and results analysis. Tools described include a moving percentage scale, an externally defined satisfaction scale applied to professionals, and a composite index combining proven behavioral indicators. Nine types of measurement strategies are discussed along with their corresponding equivalence assumptions. Attempts to deal with systematic error by the use of longitudinal design and the perils of response acquiescence and subjects' moods are also reviewed. It is concluded that none of the methodologies described addresses the full range of problems in technology transfer and diffusion of innovation that underlie the study of interaction in man machine systems in the Third World. Key factors in technology transfer that frustrate research are identified as: (1) social, behavioral, and resource requirements of the technology; (2) corresponding characteristics of the target population and its environment; and (3) compatibility of the technology and the population. (84 references) (Author/DB)

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The Cross-Cultural Study of Human-Computer Interaction: A Review of Research Methodology, Technology Transfer, and the Diffusion of Innovation

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Paper presented to the Third National Conference
on Librarians and International Development
Oregon State University, Corvallis
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ABSTRACT

This paper examines the methodological literature of cross-cultural research to establish whether the means exist (1) to identify culturally biased preconceptions implicit in human-computer interfaces and (2) to develop interfaces more attuned to the cultural diversity of users. It also addresses issues of technology transfer and the diffusion of innovation that form the context for application of potential methodologies in cross-cultural settings.

The review of methods examines questions of research design, tool construction, measurement and results analysis. An extensive bibliography is provided for further investigation of methodologies and issues.

INTRODUCTION

In the opening scene of a popular PBS television series, host James Burke brings his jeep to an abrupt halt in the Tunisian desert. Nothing can be seen for miles but sand -- and a red traffic light. Burke explains that cultural conditioning makes it irresistible for someone from an industrialized culture to come to a sudden stop at a red light -- even in as incongruous a place as the Northern Sahara (Burke, 1985). A nomadic desert dweller accustomed to roaming when and where he pleased might find the light curious -- but would not feel compelled to stop.

This cultural divide in response to the world and its technologies underlies the current review of methodologies applicable to the study of human-computer interaction (HCI).

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It is the premise of this review that cultural conditioning affects individuals' responses to technology and that in Third World countries such conditioning can seriously impede the improved transfer of information and gains in productivity anticipated from the use of computerized equipment. Specifically, the review examines the precept that cultural factors must be taken into account if human-computer interfaces are to be effective, whether in the Third World or in culturally diverse subcultures of the industrialized North.

With the notable exception of recently introduced systems capable of displaying Arabic script and kanji, human-computer interfaces thus far have relied upon Northern requirements for their implementation. This paper examines the methodological literature of cross-cultural research to establish whether the means exist (1) to identify culturally biased preconceptions implicit in human-computer interfaces and (2) to develop interfaces more attuned to the cultural diversity of users. Of special interest are methodologies used for human factors and economic development research in the Third World that may be adapted to study the cultural aspects of interface design.

The difficult context in which HCI research must be conducted in non-Northern societies is examined in a discussion of selected issues in technology transfer and the diffusion of innovation.

PROBLEMS IN METHODOLOGY: AN OVERVIEW

Researcher Bias

Some difficulties in studies of non-Northern cultures stem from researcher bias regarding (1) the intrinsic value of technology and (2) the methodologies to be applied in examining user populations. For example, most research in the Fifties and Sixties assumed that concepts to be transferred were always beneficial to Third World populations (M. Dosa, 1980). The only question was whether people would accept technology by adopting it outright or by adapting it.

Also, researchers trained in particular methodologies find it difficult to accept other approaches and thus to collaborate with colleagues who espouse those approaches. For example, should only "facts" such as productivity data be collected, should the perceptions of users be recorded, or should both be studied?

Measurement

Furthermore, interpretation of the meaning and importance of measurements changes depending upon situation. Allegedly standard international terms and economic

definitions may fail when used in varying cultural contexts and with "proxy" (second hand) responses. Also, people's problems, perceptions and coping behavior are not always measurable by the quantitative methodologies in widespread use. Personal interviews which combine quantitative and qualitative data collection may be more likely to detect cultural, social and behavioral patterns.

Quality of Life

Another potential solution to the measurement dilemma is the use of Quality of Life (QOL) indicators, which reflect linkages among health, housing, work and other conditions. Such indicators form a tool to bridge the physical, socioeconomic and cultural distances between the poor on one hand and international donors and researchers, on the other (M. Dosa, 1980). They also provide an alternative to traditional, economically based measures of the success or failure of development projects. However, in many environments QOL indicators do not include user access to technological opportunities. This omission may bias research data in favor of indigenous educated elites.

On balance, the QOL approach may offer a useful model for the study of culturally specific aspects of human-computer interfaces. Both QOL and HCI must deal systematically with high subjectivity in the collection of attitudinal data. In particular, QOL analyses of the perils of self-report in situations where researcher and subject are of different cultures might aid substantially in attempts to assess the responses of Third World computer users.

RESEARCH METHODOLOGIES

A substantial literature addresses cross-cultural aspects of research design, tool construction, measurement, and results analysis.

Research Design

The leading journal in QOL studies is Social Indicators Research. In it, Wood and Johnson (1989) examined the question of whether quantitative data provide a consistent and valid representation of subjects' attitudes. They compared quantitative and qualitative data from a group of 15 elderly subjects who had participated in both a survey study of life satisfaction and an intensive qualitative study of loneliness, social activities and social relationships.

Wood and Johnson felt that the scale values of satisfaction selected by subjects in the quantitative study were at best a superficial representation of actual feelings. Although the authors found that quantitative cluster analysis could be useful in identifying categories, they felt

structures developed by such techniques indicated little about what the categories truly represent (i.e., underlying phenomena). They concluded that quantitative approaches are of limited utility in studies of the quality of life, and suggested that such techniques are most appropriate as a supplement to qualitative methods.

Wood and Johnson noted that researchers had difficulty interpretating quantitative data because of apparent unsystematic discrepancies (random errors) between survey responses and direct observation. Also, they reported that researchers had no clear understanding of what response options meant to subjects or whether response categories represented comparable life situations for the various subjects.

Tool Construction

The statistical and structural nature of tools developed for data collection can drastically affect findings. Characteristics of the tools themselves or the ways in which they are presented to subjects can confound important variables.

The Quality of Life

Johnson (1988) acknowledged that the diverse elements that comprise QOL for individuals and social groups are each subject in principle to some form of measurement. But no satisfactory method had been devised whereby the various measurements could be reduced to a single metric. A common QOL metric is needed because without such an index, observed changes among individual factors cannot be compared. A single-figure index would allow the gauging of changes in indicators.

Johnson attempted to construct such an index, but did not claim to solve fundamental difficulties (e.g., which indicators to include in a given composite construct, or how to weigh components' individual values).

The metric proposed by Johnson does not incorporate health, employment, education and public safety (as do other QOL scales). Instead, it derives its values from observed year-to-year percentage changes in the values of such indicators. In other words, it is based upon dynamic patterns of change -- on "improvement" or "worsening" -- rather than upon absolute changes in the indicators themselves.

Johnson's index is calculated in four steps:

(1) key statistical variables (indicators) for which yearly data are regularly available are selected;

(2) year-to-year percentage changes are calculated for each indicator;

(3) weighting multipliers are selected for each set of percentage changes, to allow observed variability in indicators to be expressed within roughly comparable scales, and

(4) multipliers are applied to year-to-year changes in order to obtain index values within a predetermined maximum and minimum range (e.g., +/- 50).

The common scaling of indicators allows assessment of the contribution which each component makes toward the index's summary effect. Johnson admits that the act of combining rates of change for such disparate phenomena as crime, infant mortality, and educational attainment cannot be justified on the grounds of any existing theory of social reality. However, he maintains that the act of examining index components provides insights into underlying social processes that might not otherwise be apparent. The index is roughly useful as a dependent variable in examination of discrete factors which are felt to be important in assessing subjects' perceptions of QOL. Therefore, it demonstrates whether selected factors move with or against the general feeling of quality of life.

Johnson reported (493-494) a useful summary of seven critical weaknesses of many QOL measures, taken from an article by Naomi Wish in the American Journal of Economics and Sociology (1986).

Malinowska-Tabaka (1987) developed a more focused QOL scale, for use in subjects' work environments. Examined were individual social background and elements and levels of job satisfaction among four professional groups: doctors, engineers, lawyers and teachers. Although limited due to its origin with elite groups, this index may be more useful to the study of HCI than Johnson's measure, because computerization typically is experienced first in work settings.

Malinowska-Tabaka used a Two-Stage Principal Components Analysis to generate a scale. In the first stage, a factor analysis was conducted (independently, for each profession). This identified potential composite indicators. In the second stage, the indicator list from Stage 1 was trimmed by eliminating elements not loaded significantly on the principal component (the overall satisfaction/dissatisfaction index). Then, Pearson correlation coefficients were used to establish relationships between job characteristics and background variables.

Measuring Communication Effectiveness

Koester and Olebe (1988) created a composite scale of intercultural communication effectiveness from published

values for individual indicators whose validity had been supported by field research. A behavioral approach formed the theoretical grounding for development of an eight-item index, which the authors labeled the "Behavioral Assessment Scale for Intercultural Communication" (BASIC).

Application of a behavioral approach was intended to provide a means to assess the act of intercultural communication, rather than merely assessing the predispositions of individuals or even the results of interactions. This approach also allows the effectiveness of individuals to be evaluated from a variety of vantage points, including those of other participants, expert observers, organizational supervisors, clients, or the individuals themselves.

This approach also allows measurement of current skill levels, a key component of cross-cultural HCI evaluation. Since accurate communication between researchers and Third World subjects is essential to assessing the appropriateness of HCI components, Koester and Olebe's scale could become a key content validity standard for such work.

BASIC was designed (1) to measure actual intercultural communication, (2) to support assessment as well as prediction, (3) to include the perceptions of subjects, and (4) to be easily usable by a wide variety of individuals in diverse settings.

Koester and Olebe's work was based upon research by B.D. Ruben, who advocated concentrating upon specific communication behaviors by individuals during intercultural encounters. Ruben's indicators (intended to be descriptive of intercultural competence and adjustment) included respect, nonjudgmental posture, orientation to knowledge, empathy, role behavior, interaction management, and tolerance for ambiguity. BASIC takes nine separate scales developed by Ruben and treats them as one, generating a single score of intercultural communication effectiveness. Factor analysis is used to load Ruben's nine items for the composite scale.

Koester and Olebe reported that the BASIC index exhibited a higher correlation with the composite of all indicators of communication effectiveness than did any one of its components, suggesting that the index had captured some common underlying characteristic of most indicators of effectiveness measured.

Unfortunately, it appears that BASIC may need to be calibrated for each culture in which it is used, since the universal constructs which it attempts to describe are linked to different specific behaviors in each culture.

Measurement

Although procedures used to create scales for cross-cultural research may be helpful in guiding tool development for HCI studies, reports of actual tool use (i.e.,

measurement) provide valuable insight into the complexities of actual assessment.

Strategies and Equivalence Assumptions

Hui and Triandis (1985) reviewed nine strategies of cross-cultural measurement and their underlying notions of equivalence. (Comparative equivalence is related to dimensions of abstraction-concreteness and universality-cultural difference that are key to the analysis of cross-cultural data.) Hui and Triandis maintain that to make meaningful comparisons across cultures it is necessary to increase abstraction and reduce specificity, thus establishing commonality. However, differences observed at relatively high levels of abstraction tend to be imprecise. Precision and meaningfulness appear to be reciprocal in cross-cultural research, even though most studies attempt to maximize both.

In each of the measurement strategies reviewed by Hui and Triandis, levels and types of equivalence are different. Stability over time and space also vary (some are only meaningful at a certain locations or at certain times).

The nine strategies include:

(1) Direct Comparison: The same instrument is administered to both cultures. This approach assumes that the construct being measured exists in both cultures and is operationalized equivalently.

(2) Regression: This approach is appropriate if the regression parameters for criteria or constructs to which scores are to be generalized are equivalent for both cultures.

(3) Coscoring: Weighting factors are obtained by sampling individuals from each culture, while attempting to control between-group and within-group variances. This approach presupposes the existence of equivalent conceptual/functional factors within the cultures under study. It also assumes equivalent instrument operationalization.

(4) Item Response Theory: The probabilities that subjects will respond to an item in a specified manner at various levels of a latent trait are estimated for both cultures. Statistical tests are applied to reveal the potential for lack of equivalence between cultures for particular items.

(5) Response Patterns: Ordered rankings of item difficulty for each culture are correlated. Differences in order indicate the relative difficulty of certain items

within a culture. However, specific levels of difficulty are not necessarily comparable between cultures, since items may reference different underlying attributes despite the apparent similarity of externalized cues (labels).

(6) Translation Techniques: Conceptual equivalence is attempted in the administration of tests in different languages. However, even if test instruments are translated with high accuracy linguistically, nonequivalence may remain, on abstract and conceptual levels.

(7) Internal Structure Congruence: If a construct is the same across cultures, logic suggests that it should have the same components (or internal structures) and relations among such components in each culture. Statistical procedures such as factor analysis, multidimensional scaling, maximum likelihood factor analysis, or comparison of correlation matrices may be used to investigate the anatomies of such construct relationships.

(8) The Combined Etic-Emic Approach: Using an emic approach, some researchers prefer to describe behavior using concepts expressed by members of a culture, rather than attempting to compare behavior between populations using researchers' own observations (the etic approach). The combined etic-emic approach attempts to reconcile culturally centered techniques with more traditional researcher-centered strategies that typically are concerned with measurement precision, internal validity, and universality.

(9) Nomological Network Analysis: Nomological analysis examines whether a construct is positioned within a network of related constructs in the same manner in one culture as it is in another. This technique presumes that if a construct's meaning is parallel between cultures, that construct should be positioned in the network of meanings within each culture in a similar manner. If the two networks appear similar, measurement instruments validated by the analysis are considered culturally equivalent.

These nine strategies can complement one another. Because each has its own strengths and weaknesses, Hui and Triandis recommend that either more than one approach be applied or that a number of approaches be combined. It may be especially useful to use strategies that are based upon varying assumptions of equivalence. (See Table 1, within "Results Analysis".)

Subjective Indicators

Mastekaasa and Kaasa (1989) described techniques for addressing cross-cultural measurement error in subjective

indicators research. They recommended supplementing the use of multiple indicators and direct measurement of suspected sources of error with panel designs and specialized statistical procedures. (Their analysis included a useful summary of common strategies for dealing with measurement error.) The authors suggested that systematic error can be controlled by the use of non-experimental panel studies, in which the dependent variable (subjective well-being) can vary both between subjects and within subjects (over time). Data from such panels could effectively combine cross-section and time series data, providing rich information that could be especially useful in assessing the effectiveness of training users in the operation of unfamiliar interfaces.

Self-report

Attitudes measured using self-report techniques typically are poorly related to those noted via direct observation. Torbjorn (1988) noted that self-report errors tend to suppress, mask or "wash out" statistical associations between objective, sociologically relevant indicators of well-being on one hand and self-reported quality of life, on the other. However, substantial relationships may become apparent when attitudes are correlated with other subjective or psychological variables (Mastekaasa and Kaasa, 1989).

Subjects' response acquiescence and mood-of-the-day effects may prevent researchers from gathering accurate data. Response acquiescence ("yea-saying") may be a source of systematic error even when balanced QOL scales are used. Torbjorn felt that QOL researchers have been overly optimistic in discounting undetected systematic error. He reported, for example, that some respondents offer what they presume to be desirable answers and tend to answer "yes" more often then "no", regardless of the question. Research findings suggest that such confounds may lead to underestimates of QOL among the well-educated and overestimates among older subjects.

Systematic errors in self-reporting tend to increase the apparent strength of association between these measures and other cognitive indicators that also are based upon self-report. In other words, observed correlations between constructs of theoretical and substantive interest may be due to spurious, common sources of erroneous variance. To some extent, systematic errors can be filtered from data by means of statistical techniques. However, random errors are potentially more damaging. Torbjorn demonstrated that self-report mood-of-the-day swings randomly misrepresent well-being, which in theory should be a relatively enduring phenomenon. Self-reported measures of QOL that depend heavily upon variations in mood may correlate erratically with relatively constant features of subjects' life situations.

To deal with these problems, Torbjorn recommended that

measures of response bias be included in measurement instruments. He also suggested that researchers use longitudinal (panel) experimental designs, to permit test-retest techniques for the isolation of random mood effects.

Results Analysis

The end product of measurement is data which can be evaluated. Although analysis of findings in cross-cultural HCI studies will be difficult, existing techniques from the cultural studies literature may be applicable.

Decision Making and Equivalence

Attempts to understand how individuals make decisions sometimes use the combined etic-emic approach (Sullivan, Suzuki and Kondo, 1986). Jaccard and Wan (1986) viewed such analysis as consisting of three steps:

(1) identification of decision-related etic (researcher-defined) concepts that presumably are common across cultures;

(2) operationalization of such concepts by the use of emic (subject-defined) measures unique to each culture, and

(3) application of emically defined etic constructs to facilite cross-cultural comparisons.

Such comparisons may make use of a continuum of equivalence defined by Jaccard and Wan. The continuum begins with functional equivalence (least concordance between cultures) and ends with scalar equivalence (most concordance). Functional Equivalence exists when a measure embodies the same concept across cultures despite indigenous differences in scale endpoints. Score equivalence exists when respective measures have functional equivalence plus apply a common quantitative metric. Scalar equivalence exists when measures exhibit both a common metric and common origins (matching scale endpoints).

Jaccard and Wan noted that cross-cultural studies of decision making typically apply strategies that require (1) metric but not scalar equivalence across cultures, (2) scalar equivalence within cultures (across individuals), and (3) functional equivalence for emically operationalized etic concepts. The authors' alternative approach, intended to describe group differences without making strong assumptions, would direct attention to sets of behavioral alternatives rather than to single behaviors, in an attempt to map beliefs onto behaviors.

Table 1

Acceptance Or Rejection of Equivalence Assumptions

--- Methodologies ---	--------- Equivalence Assumptions ----------				
	psychic unity of all mankind	conceptual/ functional equiv	equiv in construct operation-alization	item equiv	scalar equiv
nomological network	P	P-D	D	R	R
combined etic-emic	P	P	D	R	R
internal congruence	P	P	D	D-R	R
translation techniques	P	P	P-D	D	R
response pattern	P	P	P	D	R
item response theory	P	P	P	P-D	D-R
regression	P	P	P	P	D-R
coscoring	P	P	P	P	D-R
direct comparison	P	P	P	P	P

Notes : P = presuppose; D = demonstrate or prove; R = doubt or reject. Combinations indicate assumption transitions.
Source : After Hui, H. and Triandis, H. (1985), 147.

Philosophical Perspectives

The researcher's philosophical perspective is central to the meaning inferred from findings. In considering studies of technological development in Third World cultures, Srinivasan (1977) argued that one should be concerned with the equality of "access", not with the equality of "success" (i.e., with what individuals make of opportunities, given that the system is "fair".) In this approach, one would measure the degree to which equality of "access" exists rather than the quality of end results.

Srinivasan also suggested that one must distinguish between absolute and relative measures. Relative measures may be taken between individuals, but require a consistent environment (including skill levels and the availability of resources) if comparisons are to be valid. Using relationships and descriptions related to specific points in time may result in faulty analysis, due to the intervention of unrecognized confounding variables that discriminate one subject from another. To a certain extent, multi-method, multi-trait methods can help to reveal such confounds.

SUBSTANTIVE ISSUES

In addition to describing candidate methodologies, the cross-cultural literature also addresses two key concerns relevant to HCI studies in Third World settings: technology transfer and the diffusion of innovation. Technology transfer is the application of appropriate novel technology; diffusion of innovation is the distribution and societal penetration of such technology. The literature in anthropology, rural sociology and developmental science addresses these concerns extensively.

Technology Transfer

Appropriateness

In their review of human factors in project work, Perrett and Letherm identified three determinants of the appropriateness of technology, including (1) social, behavioral and resource requirements of the technology, (2) corresponding characteristics of the target population and work environment, and (3) compatibility of the technology and the population.

Other key considerations discussed by Perrett and Letherm included (1) identification of the intended beneficiaries of new technology, (2) the target population's location, natural setting, demography and existing technologies, (3) economic and social organization, and potential users' socioeconomic profile, and (4) existing patterns of decision making, conflict resolution and cooperation.

Ergonomic Factors and Cognition

Mansfield (1987) concluded that ergonomic factors also could be major discriminants. He noted that key variables may include anthropometrics, physiology, cognitive characteristics, perception, work attitudes, training and language translation.

For example, in most cases systems have been designed for use in an industrialized culture where operators are literate, of a certain physical size and capacity, possess some level of manipulative skill and are familiar to a certain extent with technology. By contrast, in a newly industrialized country (NIC), an operator may be illiterate, of different physical build and capacity, and undernourished. Mansfield reported that NIC worker output is only one-quarter of that expected of a European, due to nutritional and environmental factors. Technology suitable for 95 percent of Americans fits 90 percent of Germans, 80 percent of French, 65 percent of Indians, 45 percent of Japanese, 25 percent of

Thais and only 10 percent of the largest Vietnamese.

Furthermore, working conditions and hours may not be "normal". The operator's limited experience and familiarity with technology may result in increased misuse and accidents. Lower operating rates, high absenteeism and frequent personnel turnovers characteristic of some NIC environments may not be experienced often in the culture where a given technology originated.

Perhaps still more difficult are cross-cultural differences in cognition and conceptualization. Studies reported by Mansfield found that Nepalese couldn't read maps or diagrams representing geographical space; Vietnamese had difficulties understanding technical drawings and diagrams, and Chinese were more likely to choose green for "on", whereas Americans chose red.

The Challenge of Textual Interfaces

Despite the advent of iconic interfaces and direct manipulation peripherals such as mice and power gloves, attempts to design culturally neutral graphical interfaces has barely progressed beyond renewed interest in semiotics among cognitive psychologists. Many systems currently available still rely upon text to bring functionality to the user. Even if machine operation itself could become culturally independent, the linguistic basis of most information storage and retrieval would ensure that culturally discriminated textual interfaces would remain a problem in technology transfer for some time to come.

In his review of multilingual word processing, Becker (1984) proposed that "...the computer should deal with a universal notion of 'text' broad enough to include any of the world's living languages in any combination." However, the cross-cultural limitations of current computer technology become apparent immediately when workstations are expected to display simultaneously (1) Arabic script, which flows right to left in curlicues, (2) Thai, which has letters that sometimes "step around" their neighbors, frustrating phonetic order, (3) Korean, which groups letters in syllabic clusters, and (4) Chinese, which consists of tens of thousands of ideographic characters, each a miniature calligraphic composition inside its own square frame. By contrast, the English upon which so much computer technology is based is a simple (if myopic) implementation, consisting as it does of unadorned alphabetic letters laid out one after the other.

Future technology may be able to finesse such linguistic complexities if non-ethnocentric methodologies are used to study user requirements. Even so, complex data compression and expansion algorithms and data sensitive formatting will be required to accommodate the multiplicity of potential textual interfaces without exhausting memory or hopelessly degrading response time.

Keyboards may be less of a problem than displays, according to Becker. He suggested that the use of software to map any character to any key allows text in any mixture of living languages to be represented economically on a standard typewriter keyboard (provided that users can manage a wide variety of templates). It is true that computers can display virtual keyboards to users to guide management of combined, cross-cultural texts. However, such mode-specific interfaces tend to be extremely difficult in practice, require extensive training, decrease productivity and increase error rates.

The textual interface problem in cross-cultural applications may be eased somewhat by allowing users to enter text phonetically, as is done with newer kanji systems. (The computer performs phonetic conversion using lookup tables, then displays candidate standard text for users to accept or reject.)

The Diffusion of Innovation

Technology transfer may be distinguished from the diffusion of innovation by the scope of task and the length of time in which it may be performed. Technology may be transferred from one culture to another, but have limited impact until it has been diffused as an innovation to existing techniques, for appropriate activities.

Environmental Determinants

The variety and effectiveness of communication channels, social system structure and customs, and attitudes toward time are important environmental determinants of the speed and extent of diffusion of innovation. Neelameghan (1979) identified other, more specific factors that may influence the diffusion of innovation. Included were (1) whether the situation involves one-to-one or one-to-many communication, (2) whether the communication takes place within or across national boundaries, (3) whether the transfer is attempted between equals, and (4) which characteristics of the target scientific, social, political and economic environment are especially significant.

Other factors that could complicate the design and implementation of an effective methodology for assessing the diffusion of innovation include (1) users' objectives and motives, (2) differences in religious, educational, economic, social and cultural backgrounds, (3) the intimacy of contact during technology transfer, (4) prior experience with the technology and (5) differences in the richness of information implicit in competing technologies (Neelameghan, 1979).

In the case of human-computer interfaces, characteristics of the computer medium itself may impact diffusion. It may be key whether the system being transferred involves a human intermediary, and whether the machine is

owned and/or operated by an individual, institution or government. Computer technologies may be diffused more successfully than other innovations because of the user's apparent one-to-one relationship with the computer, which may mimic intimacy. Communicating directly with a machine also avoids problems characteristic of class or caste distinctions when human transfer agents are involved.

Availability Problems

Studies of human-computer interfaces that attempt more than isolated impact analyses must include observation at a variety of installed sites. Therefore, the existing diffusion (availability) of the technology under study is a key concern affecting the validity, significance and generalizability of findings.

One major impediment to the widespread study of computer technology in non-Northern cultures is the relatively small numbers of users familiar with the machines and their capabilities. As reported in a study by the OECD ("Information Activities...", 1981), initial inroads in diffusion typically are followed by a decline in use of the technology before a substantial installed base is created throughout a culture. The adoption of new technology is riddled with risk for institutions as well as users unfamiliar with its costs, capabilities and requirements. Therefore, large-scale studies will not be possible in some cultures until long after the initial introduction (transfer) of computer technology.

Diffusion is slowed in part by resistance from newly disadvantaged workers, including influential middle management. The OECD has reported that organizational units tend to be more integrated and to merge into larger departments, and more autonomy is given to work groups at lower levels of organizations with the diffusion of electronics technology. Both effects reduce the need for middle management, threatening the job security of individuals whose support is important to the success of diffusion efforts.

Studies of computerization in non-Northern cultures also are thwarted by the availability of compatible hardware and software in sufficient quantities to make results statistically significant. As J. van Gigch (1984) noted, at any given time the national origin, brand make and quality of hardware and software in the hands of consumers in Third World cultures depends upon the condition of the national economy and upon import policy (which itself is dependent upon the balance of trade). As a result, unless a study is heavily supported by major sponsors from technology exporting cultures, methods (and therefore findings) may be restricted seriously by a lack of consistency in the interfaces available to a significant numbers of users.

Contamination of Subjects

Even though studies of technology transfer and the diffusion of computer technology in Third World cultures ideally should address "average" users, in many cases only Northern-educated elites have the language skills and incentives to be subjects.

As was demonstrated in a study of Lesotho (Africa) students exposed to U.S. business school techniques (Masten & Richard, 1986), Northern acculturation of such subjects should be a major concern of HCI research. Indigenous students in the Lesotho study moderated their approaches to be more consistent with those of U.S. managers and Northern students than with the practices of managers working in their own country. This contamination of subjects occurred despite the fact that Lesotho was designated by the United Nations as one of the least developed countries in the world, in theory ensuring strong countervailing attitudes compared to U.S. perspectives and practices.

CONCLUSION

This review of cross-cultural methodologies appropriate to the study of human-computer interfaces has examined questions of research design, tool construction, measurement, and results analysis. Additionally, it has described issues in technology transfer and the diffusion of innovation which affect the chances for success in cross-cultural studies.

A number of tools were described, including a moving percentage scale, an externally defined satisfaction scale applied to professionals, and a composite index combining proven behavioral indicators.

Nine types of measurement strategies were discussed along with their corresponding equivalence assumptions. Attempts to deal with systematic error by the use of longitudinal design and the perils of response acquiescence and subjects' moods also were reviewed.

None of the methodologies described address the full range of problems in technology transfer and diffusion of innovation that underlie the study of human-computer interfaces in the Third World.

Key factors in technology transfer that frustrate research include (1) social, behavioral and resource requirements of the technology, (2) corresponding characteristics of the target population and its environment, and (3) compatibility of the technology and the population. The unique attributes of various social systems, the availability of technology, and contamination of potential subjects also pose serious challenges to the cross-cultural study of human-computer interfaces.

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